A temperature control instrument for electronic components under test.

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- european:	F25B21/04; G01R31/28G2; H01L21/66A1; H01L21/66A6; H01L23/34H; H01L23/38	WO8302527 GB2112565 EP0247927 GB2180959 US4324285 more >>
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Abstract of **EP0314481**

An instrument for controlling the temperature of electronic components under test. The instrument creates a testing environment in an enclosure within which the component contacts directly the active face of a set of back-to-back Peltier cells. Heating and cooling of the component under test is readily easily achieved by controlling the Peltier cells and test components may be easily interchanged using a removable mounting assembly. The instrument has the advantages of being small (portable), easy to operate, inexpensive to manufacture and to run and of producing very little electrical noise.

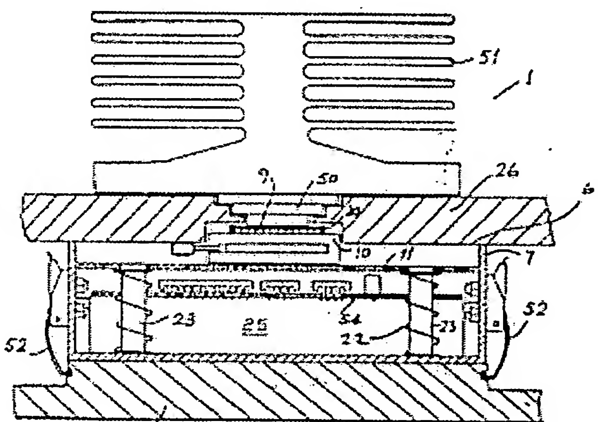

Fig.3

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(54) A temperature control instrument for electronic components under test.

(57) An instrument for controlling the temperature of electronic components under test. The instrument creates a testing environment in an enclosure within which the component contacts directly the active face of a set of back-to-back Peltier cells. Heating and cooling of the component under test is readily easily achieved by controlling the Peltier cells and test components may be easily interchanged using a removable mounting assembly. The instrument has the advantages of being small (portable), easy to operate, inexpensive to manufacture and to run and of producing very little electrical noise.

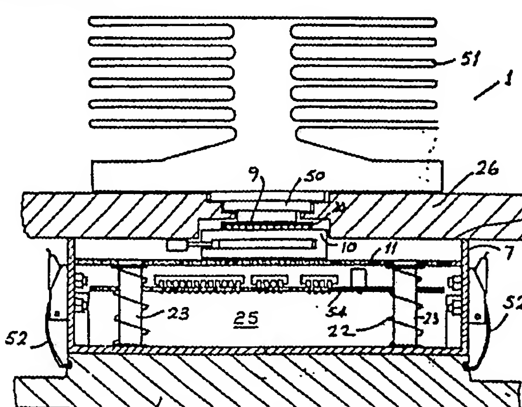

Fig.3

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Description

A temperature control instrument for electronic components under test

The present invention relates to the temperature control of electronic components under test, for example, integrated circuits, printed circuits, hybrid circuits and other electronic devices, hereinafter referred to generally as electronic components.

The temperature range over which electronic components have to be tested varies depending on the particular application. For example, in high reliability applications, such as avionics and many civil and military applications it is necessary that electronic components function over the range -55°C to +125°C. Needless to say, for many other applications there are slightly smaller temperature ranges within which components must function.

The only satisfactory way of testing such components is to provide an environment in which the component can be placed and tested. Any form of localised heating or cooling of a component under test is unsatisfactory. Accordingly, it is necessary to house the component in an enclosure within which the necessary test environment can be created. Generally, such an environment is heated by an electric heater and cooled by some form of gaseous coolant in a two-stage refrigeration system, or by a liquid coolant, for example, evaporation of liquid nitrogen in the enclosure. Unfortunately, two-stage refrigeration systems have to be used because one refrigeration unit alone is incapable of cooling over the temperature range usually required.

U.S. Patent Specification Nos. 4,426,619 and 4,734,872 (Temptronic Corporation) describe a typical system for temperature control of components within a controlled environment in which a gaseous coolant is used. The systems of these inventions include air compressors and dryers, large refrigeration units and an electrical processing unit. Such systems are extremely bulky as a large amount of space is required for the refrigeration and electrical processing units, and for storage containers of cooling gas. As the operation of these systems is complex and much equipment is required, they are extremely expensive both to manufacture and to run. Further in many such systems the desired accuracy is seldom achieved. Further, these systems are extremely noisy acoustically, and, indeed, a special sound insulating room is sometimes required. Another common problem is the formation of ice on the circuit being tested caused by condensation of atmospheric moisture. Such moisture can produce unwanted electrically conducting paths. Another problem is that components associated with a component under test must generally be located at a relatively large distance from the component under test. This can lead to distortion of test signals. A further problem is that change-over between test is generally exceedingly time-consuming.

An object of the present invention is to provide a radically different temperature control instrument which does not require conventional refrigeration units with gas or liquid handling equipment associated with the prior art.

It is another object of the invention to overcome the problems of condensation associated with conventional temperature control apparatus. A further object is to provide a temperature control instrument with improved accuracy.

A still further object is to provide a temperature control instrument which is relatively simple, inexpensive and physically small, preferably portable. Another object is to allow components connected to a component under test to be located relatively close thereto, and a further object is to allow a relatively quick change-over between tests.

According to the invention, there is provided a temperature control instrument for an electronic component under test comprising:-

a test enclosure having socket means for reception of the component;

heat transfer means for heating or cooling the enclosure;

temperature sensing means for sensing temperature within the enclosure; and

a controller for controlling operation of the heat transfer means;

characterised in that the heat transfer means comprises a thermoelectric device of the type having a heat transfer active face and a reference face, maintained at a substantially constant temperature, the temperature of the active face being altered by the controller varying the magnitude and direction of current applied to the device.

The advantages of using a thermoelectric device will be immediately apparent. Firstly, there is no need for refrigeration units and associated liquid or gas holding equipment. Accordingly the instrument is small and indeed portable. A further advantage is that the instrument is relatively easy to control as temperature change is achieved by simply varying current through the thermoelectric device.

In one embodiment, the active face is arranged to contact the component under test. By doing this, the component is heated and cooled more quickly than by convection heat transfer alone.

Preferably, the socket means and the thermoelectric device are separately mounted and movable with respect to each other by a mounting assembly between a closed position in which they are adjacent and an open position in which they are spaced apart. In this latter embodiment, the mutual movement between the socket means and the thermoelectric device is substantially perpendicular to its active face.

This has been found to be a convenient arrangement for facilitating insertion and removal of a component for test. The perpendicular movement is desirable to prevent scuffing and to incur even contact for components of different size.

Ideally, the socket means is mounted in a removable housing.

This is an important feature of the invention as it facilities quick change-overs between tests by simply removing the housing and inserting another

housing with a new component.

In one embodiment, the socket means is a spring mounted within the housing so that, in use, a component in the socket is urged against the active face of the thermoelectric device.

This arrangement ensures that a component is always positioned adjacent the thermoelectric device during a test.

Ideally, the active face of the thermoelectric device forms part of an internal surface of the instrument and the housing has upstanding walls for contacting this internal surface in the closed position to surround the active face of the thermoelectric device and form the test enclosure

This is a particularly convenient arrangement as the enclosure is formed simply by pushing the housing against the internal surface.

The housing preferably includes means for supporting circuits separate from the test enclosure for connection to a component under test.

By supporting circuits connected to a component under test in this way, signal degradation is prevented. This associated circuits are not subject to temperature extremes and may be easily mounted inside the housing.

Preferably the housing is mounted on a door of the instrument and:-

the door is mounted on a pivot hinge spring urged away from the active face of the thermoelectric device;

a stay is adjacent one end pivotally mounted on the door and adjacent its other end pivotally and slidably mounted on a longitudinal guide, substantially perpendicular to the active face; and

a stop for preventing further pivotal movement of the stay when on closing the door, the door has reached a position substantially parallel to the active face, closure of the door being completed by pushing the door substantially perpendicularly inwards towards the active face.

This is a very simple and effective way of forming the enclosure in a movement perpendicular to the active face. The door is substantially horizontal when open so that the housing may be easily mounted thereto, however, the final action is not pivotal, but perpendicular to provide the above advantages.

According to another aspect, there is provided a method of operating a temperature control instrument as claimed in any preceding claim in which the temperature of a component under test is controlled by comparing the sensed actual temperature of the component with a user target temperature and with reference to the time difference between peak values of previously sensed actual temperatures.

Ideally, when the test enclosure is open, there is performed the additional step of heating the enclosure a predetermined amount above ambient temperature.

The invention will be more clearly understood from the following description of a preferred embodiment thereof, given by way of example only with reference to the accompanying drawings in which:-

Fig. 1 is a perspective view from above of a temperature control instrument for electronic components under test according to the invention;

Fig. 2 is a cross-sectional side view of portion of the instrument illustrating an enclosure in the open position;

Fig. 3 is a cross-sectional plan view of the portion of the instrument illustrated in Fig. 2 with the enclosure in the closed portion;

Fig. 4 is a perspective view from above of a removable assembly of the instrument;

Figs. 5(a) and 5(b) are diagrammatic side views illustrating portion of the instrument in more detail; and

Fig. 6 is a block diagram illustrating operation of portion of the instrument.

Referring to the drawings, and initially to Figs. 1 to 4, there is illustrated a temperature control instrument for electronic components under test, indicated generally by the reference numeral 1. The control instrument 1 is of portable, stand-alone construction and comprises a rectangular box casing 2 housing a controller, incorporating instrument control circuits, not shown, an input interface keypad 3 and an output interface liquid crystal display 4. The control instrument 1 also has an internal surface 6 formed by silicon seals 26 and a component recess 8 surrounding the active face 9 of a thermoelectric device, in this case a set of three back-to-back Peltier cells 50 connected, at their other end namely at the reference face to an air cooled heat sink 51. A socket 10 is mounted on a mounting board 11 spring-mounted within an interchangeable open ended housing formed by a die-cast box 12 which is in turn releasably mounted on a door 13 by catches 52. The door 13 is arranged to initially pivot upwards to a vertical position spaced-apart from the casing 2 and to then move inwardly perpendicular to the active face 9 to form a thermal enclosure as illustrated in Fig. 3. The arrangement to achieve this is illustrated in Figs. 5 and 6 described in detail below.

The socket 10 is for reception of integrated circuits (IC's) such as that shown and identified by the reference numeral 20 and includes a conventional pin locking mechanism operated by a lever 21 to allow a user secure integrated circuit pins within the socket. The mounting board 11 is resiliently mounted on the base of the die-cast box 12 by outwardly biased mounting springs 22 and pillars 23. Components connected to the IC 20 are mounted on a circuit board 54 mounted on the pillars 23 below the mounting board 11. Foamed plastics insulating material 25 is inserted in the die-cast box 12. Electrical leads 30 for the socket 10 are connected through the rear side of the die-cast box 12 (see Fig. 4).

In use, an integrated circuit to be tested is mounted in the socket 10 and the die-cast box 12 is clipped to the inside of the door 13 and the electrical leads 30 are then connected to a particular board, not shown, to be used in the testing of the integrated circuit 20. The required connections are made to the circuit board 54. The door 13 is then closed so that the integrated circuit 20 engages the active face 9 of the Peltier cells 50 within the recess 8. This closed position is illustrated in Figs 1 and 3. When in the

closed position, the die-cast box 12 and the silicone seal 26 form a thermal insulating enclosure therebetween, within which the integrated circuit 20 directly contacts the Peltier cells 50. The keypad 3 is then used to control operation of the Peltier cells to provide whichever temperatures are required according to various tests to be carried out. When the door 13 is open, the Peltier cells 50 are heated slightly to prevent condensation of atmospheric moisture on the component under test. This is automatically carried out as a sensor (not shown) detects opening of the door.

It will further be appreciated that by using a die-cast box such as the box 12, manufacturing costs are reduced and the assembly may be easily removed and inserted within the temperature control instrument 1. The ability to quickly interchange die-cast boxes facilitates testing of circuits of different shapes and sizes with a minimum delay time between tests. The die-cast box 12 (which may be earthed) also provides excellent electrical screening during tests. As the device 1 incorporates a linear regulator type power supply and the control circuits are located as far as possible from the enclosure, electrical noise is further reduced.

Referring now to Figs 5(a) and 5(b), the operating mechanism for the door 13 is illustrated in more detail. Like parts are assigned the same reference numerals. The door 13 is connected to the casing 2 by a stay 40, which is pivoted to an upper pin 41 in the door 13 and at the other end to a movable pin 42 mounted within an upper guide slot 43 in the casing 2. The door 13 includes another, lower fixed pin 44 engaging a lower lateral slot 45 in the casing 2. The lower pin 44 is biased outwardly by a spring 46 connected to the casing 2. The door 13 further comprises a stop 47 above the upper pin 41.

In the open position, the spring 46 pushes the lower pin 44 outwardly against the outer end of the lower slot 45. As the door 13 is pushed upwards the stay 40 moves inwardly in the slot 43 and when in the vertical position the door 13 cannot pivot further around the upper pin 41 due to the action of the stop 47 (See Fig 5(b)). At this stage, the door 13 is still spaced-apart and to form the enclosure, the door 13 is pushed inwardly against the action of the spring 46. In this way, contact between the component under test and the active face of the thermoelectric device is made evenly thus giving a good engagement for heat conduction and preventing scuffing.

Referring now to Fig. 6, the operation of the control circuit of the device 1 is illustrated in block diagram form. Like parts are assigned the same reference numerals. A microprocessor 30 controls the operation of the control circuits. K-type thermocouples 31 are mounted at the socket 10 for sensing the temperature of a component under a test. The thermocouples 31 are connected to an associated amplifier 32 which is in turn connected to an analogue to digital converter, in this case, a voltage to frequency (V\F) converter 33. The V/F converter 33 is connected to a counter in the microprocessor 30. The microprocessor 30 is connected at its output to a digital to analogue (D/A) converter 37, which is in turn connected to a power amplifier 38 for the Peltier cells 50. A separate, independent protection circuit 34 Comprising K-type thermocouples for detecting the temperature of the heat sink and Peltier cell active face is also provided.

In operation, the V\F converter 33 is operated with an offset frequency of approximately 20 kHz so that a zero voltage input gives a count of approximately 8000 cycles in a 400 millisecond counting period. This offset is provided so that negative input voltages to the V\F converter do not result in zero or negative frequency output. The thermocouple amplifier 32 is connected to the V\F converter 33 via parallel resistors R1 and R2, R2 being connected to a reference voltage supply. The microprocessor 30 is programmed to allow for inaccuracies in the values of R1 and R2 by subtracting a frequency value corresponding to the value obtained when the analogue input to the V\F converter 33 is zero. Needless to say, the microprocessor 30 is also programmed to allow for non-linearities in thermocouple output. As the power amplifier 38 is arranged to supply current in either direction, the distortion caused in switching over of separate supplies is avoided.

The microprocessor 30 drives the Peltier cells 9(a) with the maximum permitted current if the difference between the actual temperature and the desired temperature is more than 12°C. The maximum current value used for cooling is different from that used for heating because the Peltier cells 50 behave differently for heating and cooling.

The independent protection circuit 34 acts to cut-out operation of the device 1 in the event of temperature extremes being detected at the heat sink or Peltier cell active face. Such extremes can be caused, for example, by the absence of a component with the device switched on. It will be appreciated that this is an important feature as Peltier cells may be easily damaged by temperature extremes.

The microprocessor 30 includes an IEEE-488 computer interface to allow the testing device 1 to be controlled by a remote computer if desired. Various control constants such as gain constants and addresses are stored in non-volatile memory in the microprocessor 30. These constants can be changed by a user via the keypad 3 when it is desired to calibrate the instrument 1. Alternatively, the constants may be changed through the IEEE-488 computer interface. It will be appreciated that this facility allows the instrument to be automatically calibrated for accuracy and to have different control constants for different sizes of component under test. It also provides for self-tuning either by a user or by a remote computer. A user may tune the instrument by noting the mean maximum actual temperature swings from the target temperature for a component under test and the mean time period for these swings and then inputting those valves via the keypad 3. To avoid electrical noise, changes over a period of a few seconds in the output value of the D\A converter 37 are prevented

The liquid crystal display 4 displays actual temperature and the target temperature for a component under test and also the elapsed time since the

last change in desired temperature. Error messages are also displayed.

It will be appreciated that the instrument 1 need not necessarily be used as a stand-alone unit as the microprocessor 30 may be connected by an IEEE-488 interface to a remote computer for form an automatic test facility and further, an operator can control the complete test facility from the front panel of the testing device 1.

As the thermoelectric device is used for heating and cooling, the instrument 1 is only a fraction of the size of presently known thermal control apparatus. There is no need for refrigeration units or gas storage cylinders. As its construction is extremely simple, the control instrument of the invention is more reliable than known thermal control instruments and requires little maintenance. It is envisaged that both the cost of manufacturing and the maintenance costs will be much lower than heretofore. Another advantage of this construction of thermal testing device is that very little acoustic noise is produced. This is in contrast to presently known thermal testing devices, the refrigeration units of which generate excessive noise and, indeed, a special room is often required to house them. As a component under test is in direct contact with the Peltier cells and there is a relatively small thermal enclosure, excellent temperature control within a tolerance range of + -0.1°C has been achieved. A further, advantage is that circuits associated with a component under test may be located closely thereto without being subject to temperature extremes.

As current through the Peltier cells is varied gradually, the problems caused in Peltier cells by sudden voltage changes are avoided. Further, by maintaining a constant current level in the Peltier cells, electrical noise is avoided. It will be appreciated that these are significant advantages.

The instrument of the invention may include a cold accumulator. Such an accumulator would consist of a piece of metal which is cooled over a relatively long time period by the Peltier cell. When a rapid reduction in temperature is required, air from the enclosure may be passed over the accumulator and back into the enclosure.

It is envisaged that the control circuit may include a switching regulator for supplying the Peltier Cells with current switching at a very high frequency to control temperature. The advantage of this arrangement is that damage to the Peltier Cells is avoided. It is also envisaged that Peltier cell current may be maintained in direct protection to cold face temperature to obtain maximum efficiency.

As the thermoelectric device is used for both heating and cooling, the base temperature from which the instrument operates may be taken as the middle of the desired operating range. Instead of the arrangement illustrated, it is envisaged that a separate heating element may be used for heating the enclosure, the thermoelectric device being used only for cooling. In this case, it may not be convenient to operate from a base temperature in the middle of the range. Needless to say, the heat sink may be cooled by air or a water or any other means.

Claims

1.A temperature control instrument (1) for an electronic component (20) under test comprising:-
a test enclosure having socket means (10) for reception of the component (20);
heat transfer means for heating or cooling the enclosure;
temperature sensing means (31) for sensing temperature within the enclosure; and
a controller for controlling operation of the heat transfer means;
characterised in that the heat transfer means comprises a thermoelectric device (50) of the type having a heat transfer active face (9) and a reference face (51), maintained at a substantially constant temperature, the temperature of the active face (9) being altered by the controller varying the magnitude and direction of current applied to the device (50).

2.A temperature control instrument as claimed, in claim 1 in which the active face (9) is arranged to contact the component (20) under test.

3.A temperature control instrument as claimed in claim 1 or 2 in which the socket means (10) and the thermoelectric device (50) are separately mounted and movable with respect to each other by a mounting assembly between a closed position in which they are adjacent and an open position in which they are spaced apart.

4.A temperature control instrument as claimed in claim 3 in which the mutual movement between the socket means (10) and the thermoelectric device (50) is substantially perpendicular to its active face (9).

5.A temperature control instrument as claimed in any preceding claim in which the socket means (10) is mounted in a removable housing (12).

6.A temperature control instrument as claimed in claim 5 in which the socket means (10) is spring mounted within the housing (12) so that, in use, a component (20) in the socket means (10) is urged against the active face of the thermoelectric device.

7.A temperature control instrument as claimed in claim 5 or 6 in which the active face (9) of the thermoelectric device (50) forms part of an internal surface (16) of the instrument and the housing (12) has upstanding walls for contacting this internal surface (16) in the closed position to surround the active face (9) of the thermoelectric device (50) and form the test enclosure.

8.A temperature control instrument as claimed in any of claims 5 to 7 in which the housing (12) includes means for supporting

circuits (54) separate from the test enclosure for connection to a component (20) under test.

9.A temperature control instrument as claimed in any of claims 5 to 8 in which the housing (12) is mounted on a door (13) of the instrument.

10.A temperature control instrument as claimed in claim 9 in which:-
the door (13) is mounted on a pivot hinge spring urged away from the active face (9) of the thermoelectric device (50);
a stay (40) is adjacent one end pivotally mounted on the door (13) and adjacent its other end pivotally and slidably mounted on a longitudinal guide (43), substantially perpendicular to the active face (9); and
a stop (47) for preventing further pivotal movement of the stay (40) when on closing the door (13), the door (13) has reached a position substantially parallel to the active face (9), closure of the door (13) being completed by pushing the door (13) substantially perpendicularly inwards towards the active face (9).

11.A method of operating a temperature control instrument as claimed in any preceding claim in which the temperature of a component under test is controlled by comparing the sensed actual temperature of the component with a user target temperature and with reference to the time difference between peak values of previously sensed actual temperatures.

12.A method as claimed in claim 11 in which, when the test enclosure is open, there is performed the additional step of heating the enclosure a predetermined amount above ambient temperature.

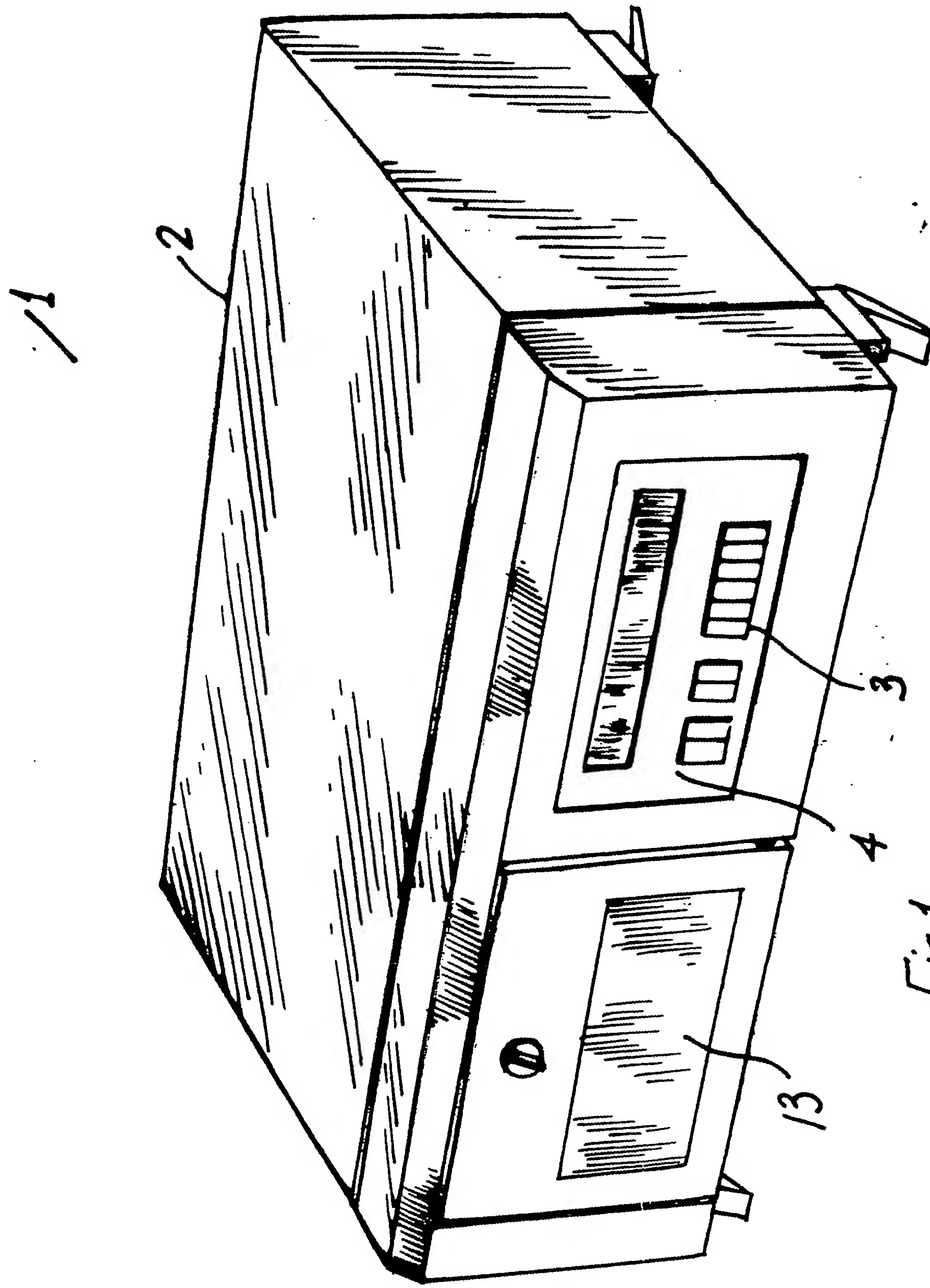

Fig.1

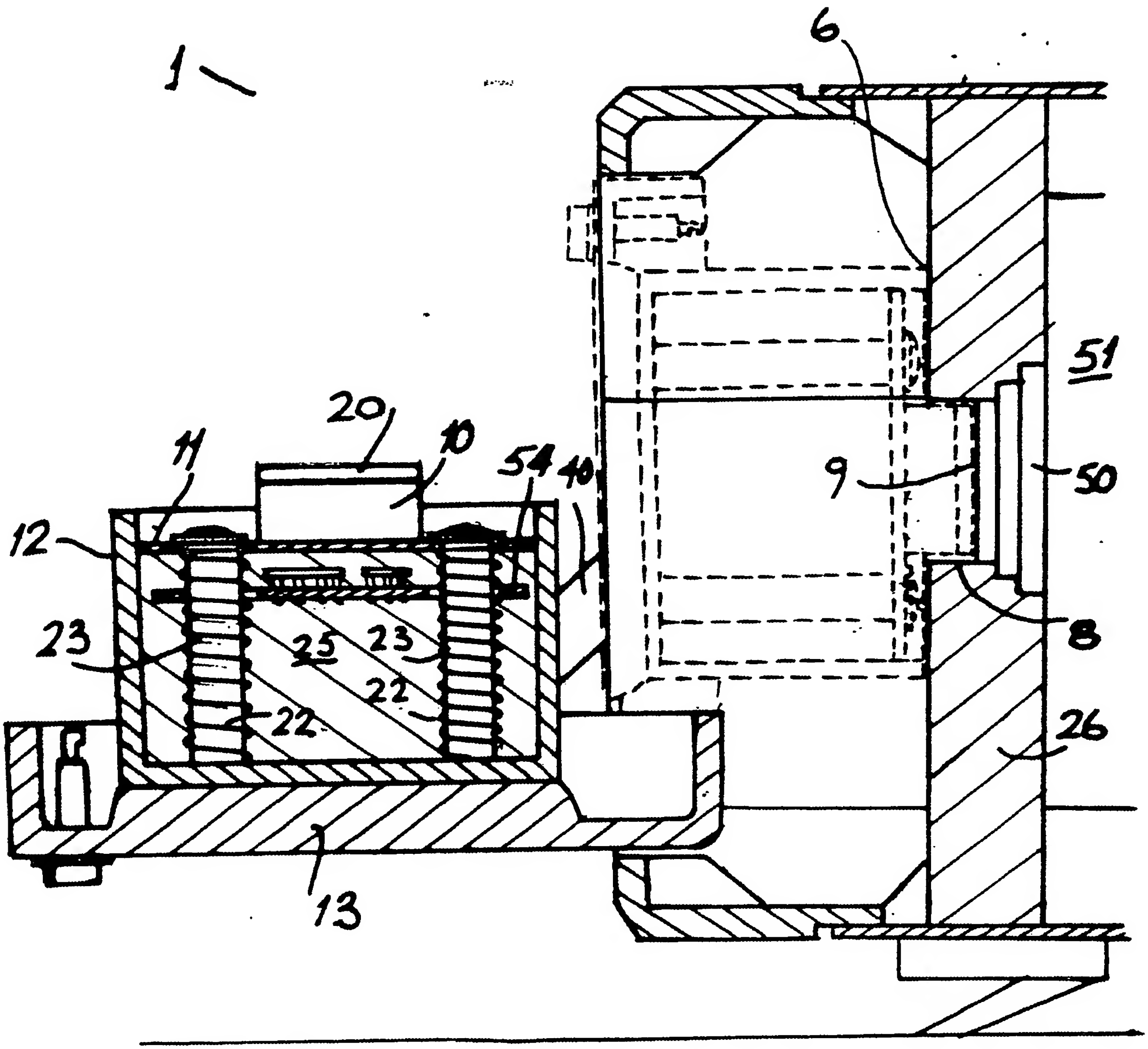

Fig. 2

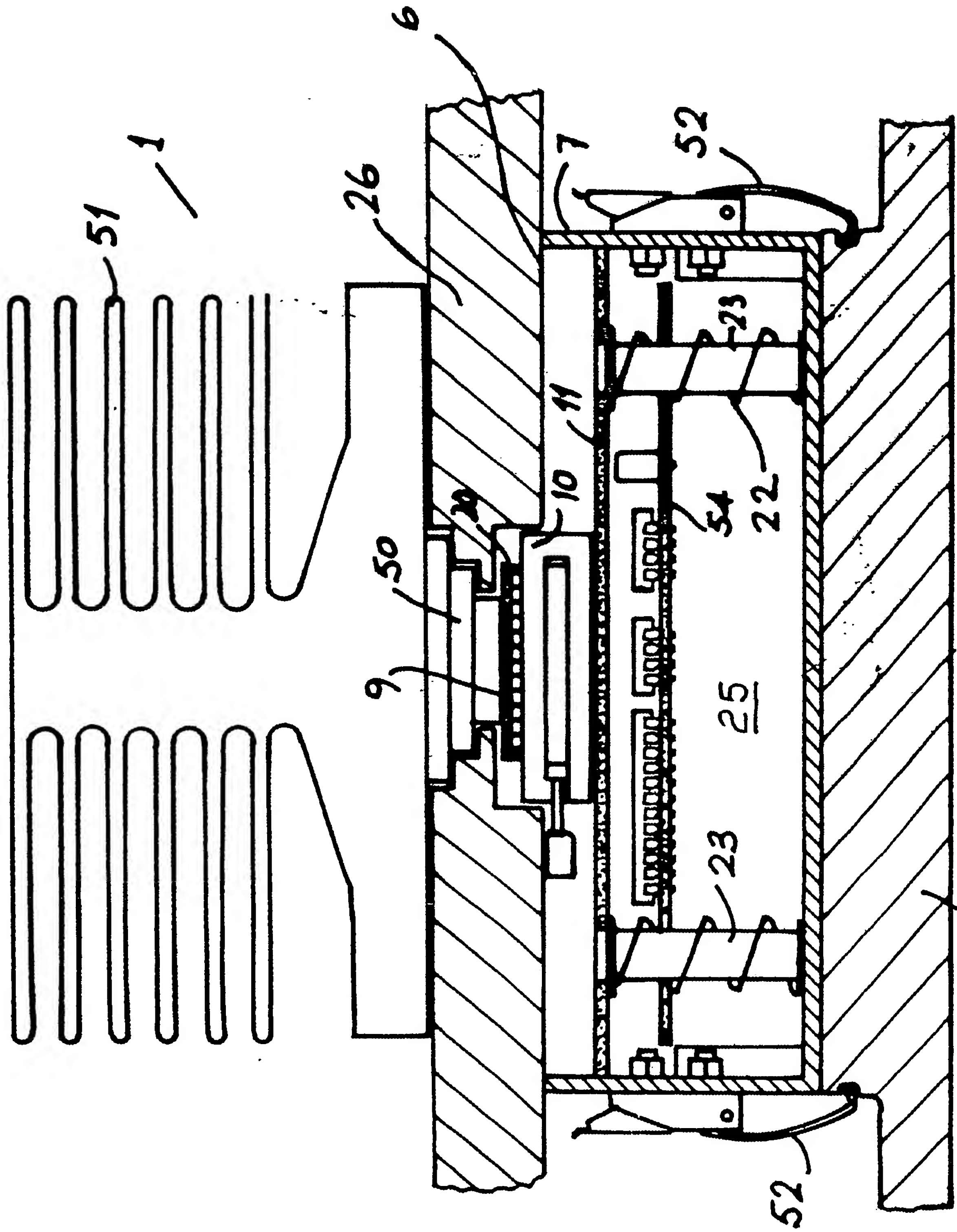

Fig.3

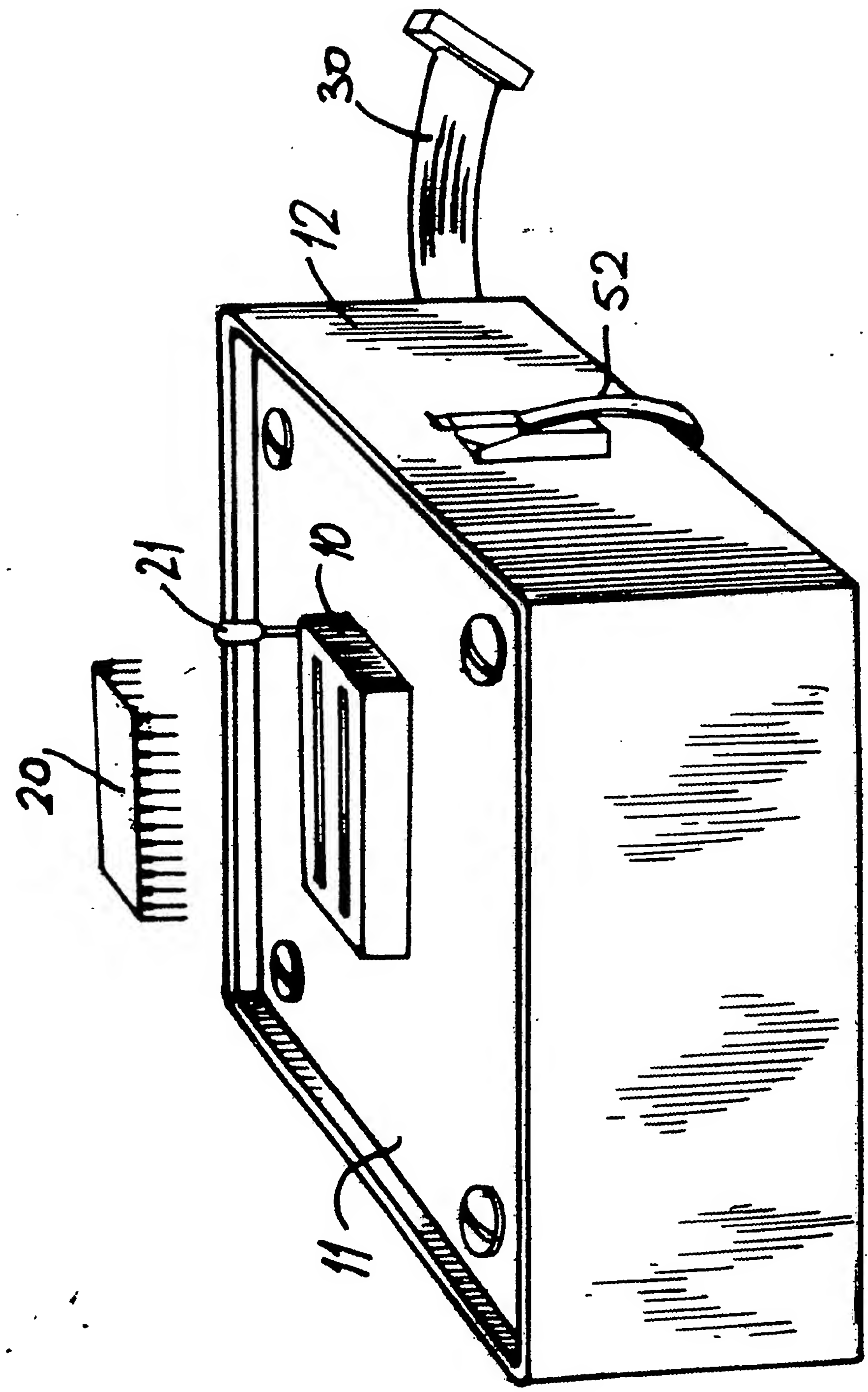

Fig.4

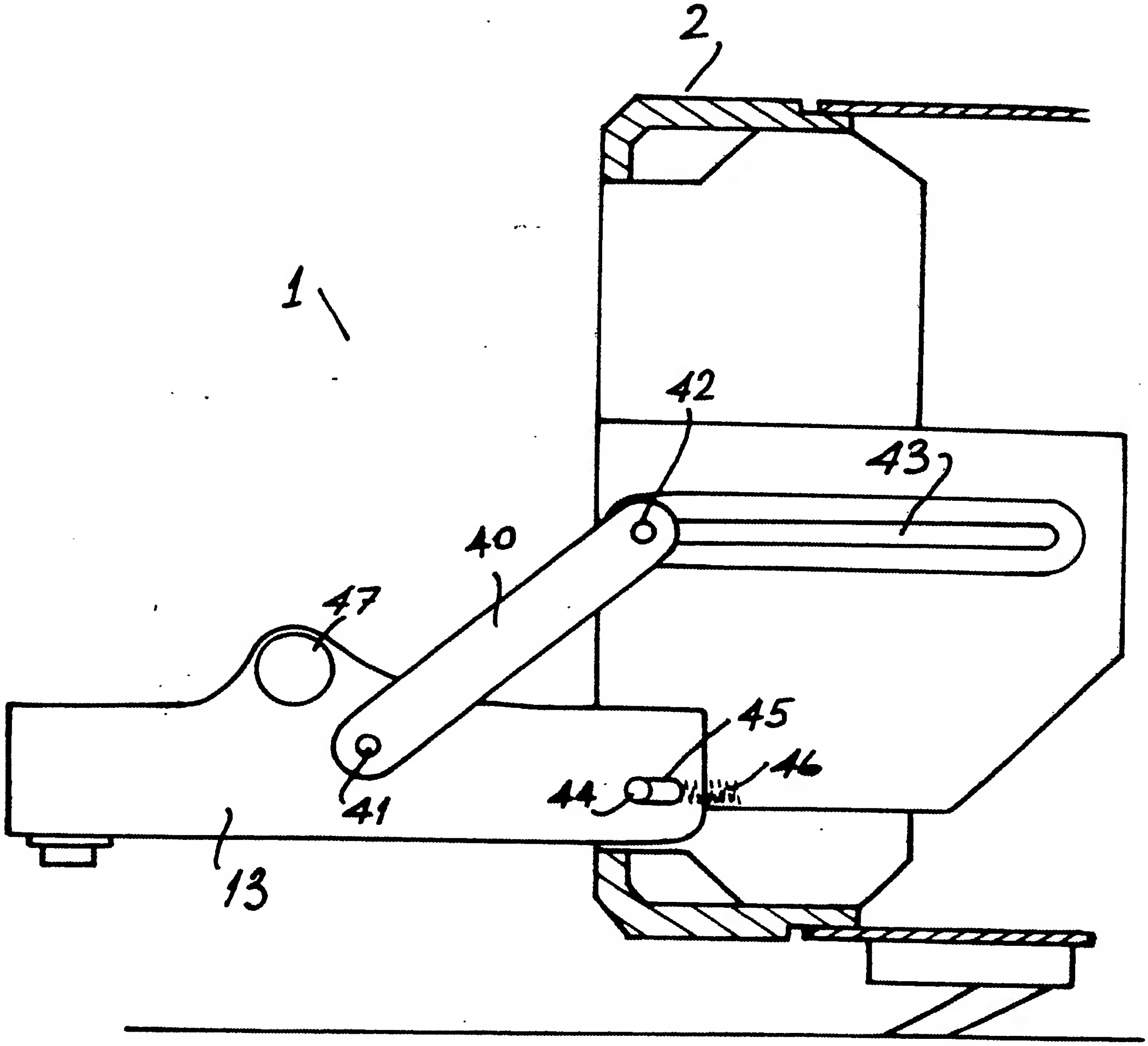

Fig. 5(a)

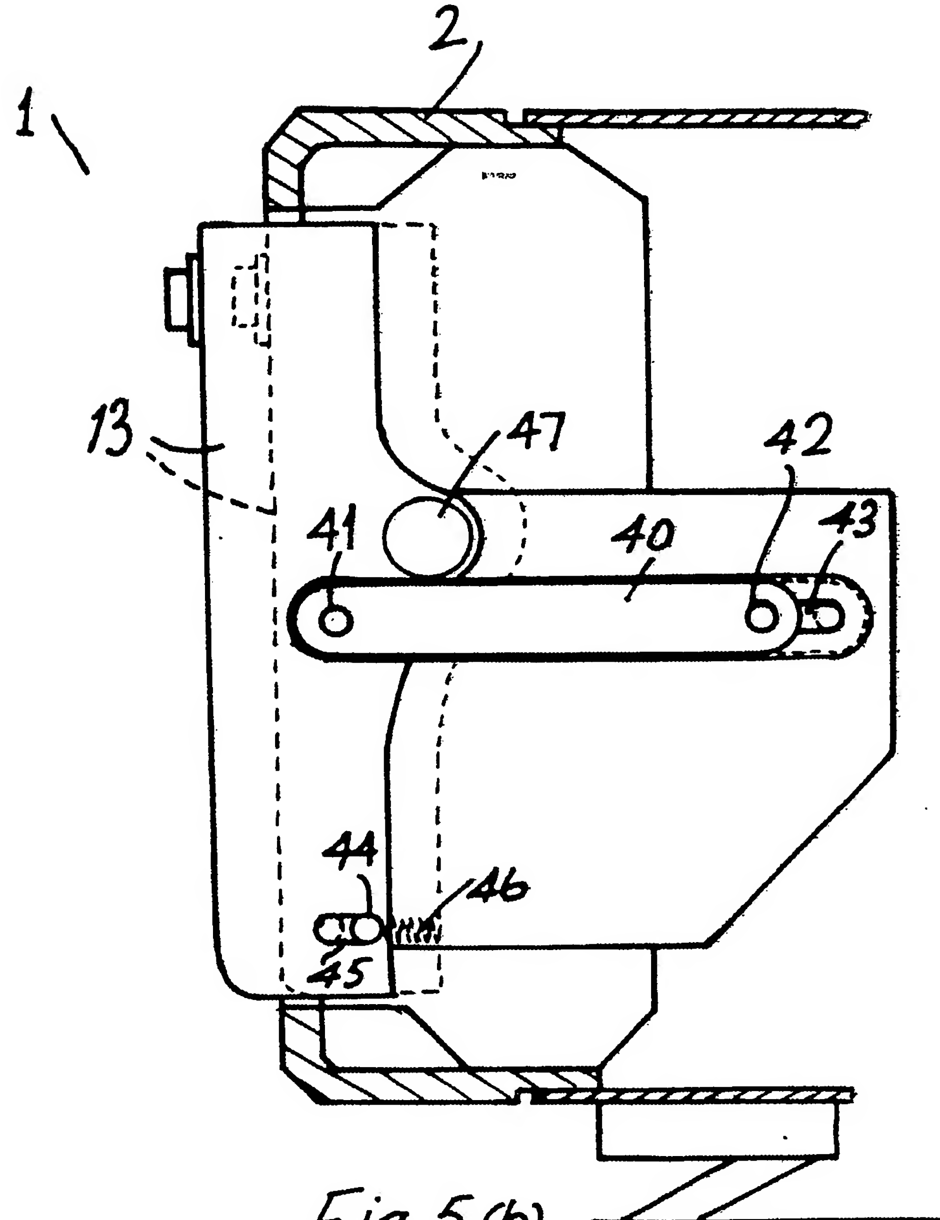

Fig. 5 (b)

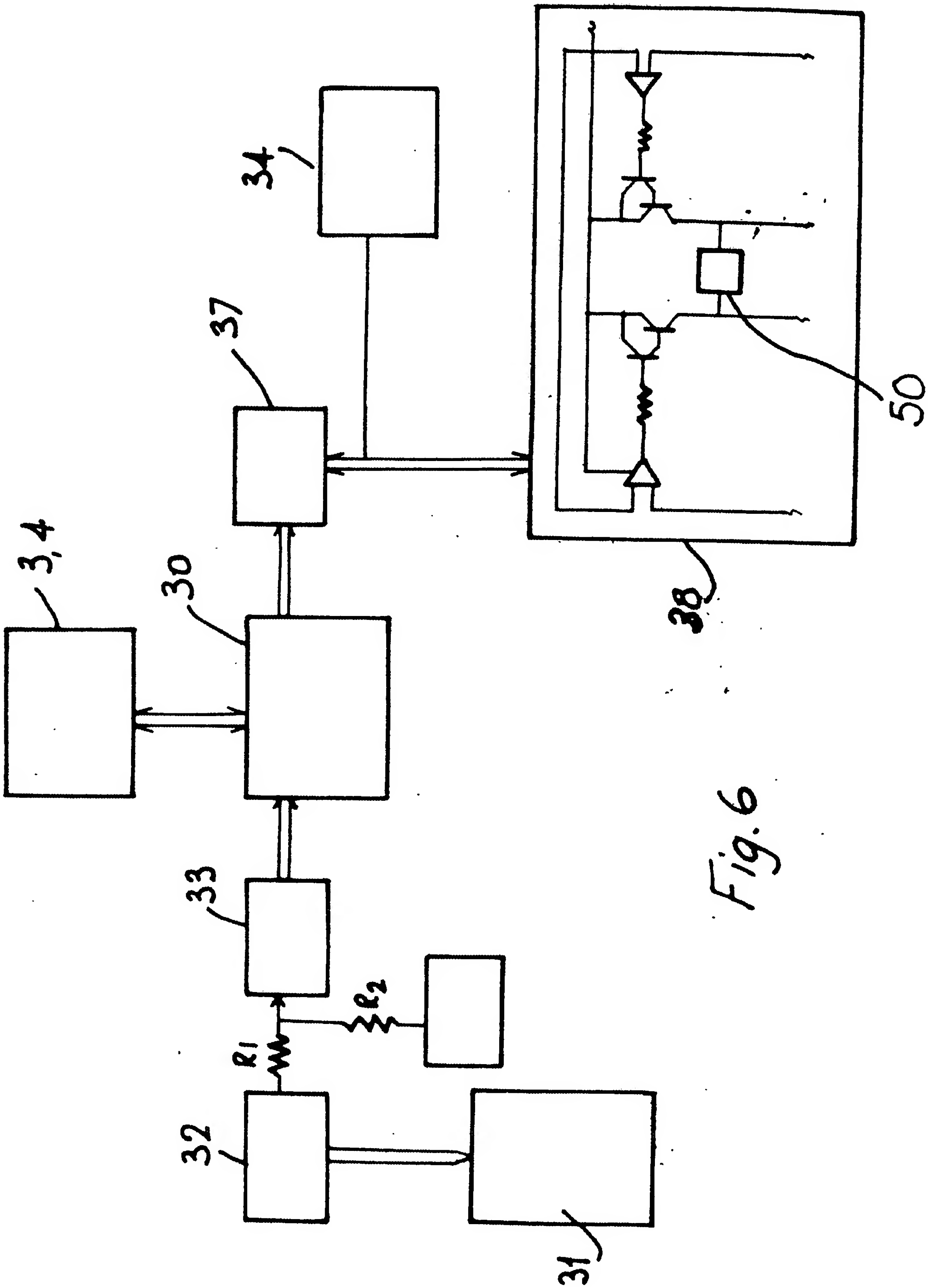

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number

EP 88 31 0122

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X A	WO-A-8 302 527 (NCR CORP.) * Page 1, line 3 - page 2, line 25; page 9, lines 5-37; figure 1 *	1 3-7	G 01 R 31/28 H 01 L 23/38
A	GB-A-2 112 565 (FERRANTI LTD) * Page 4, lines 9-69; figure *	2	
P,A	EP-A-0 247 927 (FUJITSU LTD) * Page 7, line 26 - page 8, line 22; figures 2,4 *	6,8	
A	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 9, no. 3, August 1966, page 342, New York, US; R.C. CHU: "Thermoelectric cooling for memory arrays"	9-10	
Y	GB-A-2 180 959 (SHARETREE LTD) * Page 2, line 21 - page 3, line 4; figure 6 *	11	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
Y	US-A-4 324 285 (HENDERSON) * Column 6, line 28 - column 7, line 22; figures 1,7-8 *	11	H 01 L 23/00 H 01 L 21/00 G 01 R 31/00
A	IEEE TRANSACTIONS ON NUCLEAR SCIENCE, vol. NS-33, no. 6, December 1986, pages 1605-1609, IEEE, New York, NY, US; W.A. KOLASINSKI et al.: "The effect of elevated temperature on latchup and bit errors in CMOS devices" * Page 1605, column 2, lines 20-46 *	11	
A	US-A-4 253 515 (SWIATOSZ) * Abstract; figure 1 *	12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07-02-1989	TRELEVEN C.

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